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LARS Contract Report 083179

E83-10144
NASA-CR-167787

Quarterly Progress Report

Evaluation of SLAR and Thematic Mapper MSS Data for Forest Cover Mapping Using Computer-Aided Analysis Techniques

Contract No. NAS 9-15889

Reporting Period: June 1, 1979 - August 31, 1979

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NASA Lyndon B. Johnson Space Center

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(E83-10144) EVALUATION OF SLAR AND THEMATIC MAPPER MSS DATA FOR FOREST COVER MAPPING USING COMPUTER-AIDED ANALYSIS TECHNIQUES Quarterly Report, 1 Jun. - 31 Aug. 1979 (Purdue Univ.) 28 p HC A03/MF A01 CSCL 02F G3/43

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I. ACTIVITIES OF THE PAST QUARTER

Activities to date have been primarily concerned with the following:

A. Review of the Pertinent Literature

B. Mission Planning

C. Data Collection

D. Reference Data Acquisition

E. Construction of the Cover Type Map

F. Reformatting and Geometric Correction of the MSS Data

G. Acquisition of the LANDSAT Data

Each of these areas of activity are more thoroughly discussed in the following paragraphs.

A. Literature Review

Perusal of the literature concerning radar, and spectral band/information correlation has been on-going since the approval of the study was received. Much of the literature review effort has been focused on developing a more thorough understanding of the relationship between earth surface feature characteristics and the amplitude of the radar return. Effort has also been focused on gathering information on numerical approaches to radar data analysis. In addition to studying literature dealing with radar, a review has also been conducted into work with MSS data and the spectral and spatial characteristics of earth surface features. While the literature is replete with articles concerning reflectance properties of plant matter and soil surface characteristics in different segments of the spectrum, there appears to be a paucity of information of consequences to classification efforts due to the spatial resolution of the scanner system in comparison to size of the individual cover types.

B. Mission Planning

The NASA aircraft mission in support of this contract was planned to coincide in time and geographical location with a flight mission scheduled by F.P. Weber of the U.S.F.S. National Forestry Applications Program. Mid-April to late May was considered preferable due to the deciduous tree species of the area being in full leaf, yet growth of the spring-planted crops is not sufficient to result in spectral confusion. This allows maximum separability of the forested and agricultural areas. Frontal weather patterns are also frequent enough at this time of the year to allow aircraft data to be collected under conditions of minimal haze densities and cloud cover.

The selected study area is located in north-central South Carolina. (see Figures 1 & 2). It covers nearly all of Kershaw county, the northwestern corner of Sumter county, and the northeastern corner of Richland county. The center of the study area lies approximately 24 miles northeast of Columbia, South Carolina. The total area of the study site is approximately 290 square miles, or 185,600 acres.

The area occurs on the border of the Peidmont Plateau and the Coastal Plain. (see Table 1 for flight line geographical coordinates). The elevation above mean sea level ranges from approximately 110 feet to 500 feet; mean ground datam is app. 380 feet. The rationale for selecting this area is based on: 1) the area contained a sufficient diversity of land-use and cover type classes to serve in assessing the classification capabilities of the different data sets, 2) there is a sufficient amount of repetition and aerial extent of each land-use and cover type class to provide a statistically sound sample size for each type, 3) topographic releif is small, and topography is therefore considered insignificant as a source of variance in reflectance patterns, 4) scale of land-use patterns is sufficiently small to reflect real differences in information generation capabilities due to spatial resolution differences, if such capability differences are found to exist, 5) the area is felt to be representative of forested areas of the southeast, an area of major significance as a source of forest products.

C. Data Collection Mission

The data required to conduct this study was to be collected from both the NC-130 and RB-57 aircrafts. The NC-130 mission was flown on May 2, 1979. However, the RB-57 mission was never flown.

The NC-130 aircraft houses the NS001 scanner system, which basically corresponds to the channel configuration of the proposed Thematic Mapper (Tucker, 1978). Table 2 displays the channel configuration and respective spectral bands of the NS001 and the proposed TM scanner system. Scanner data was collected in all channels except channel 7 (2.08-2.35 μm) due to failure prior to the flight. Aerial photography in both color and CIR was obtained concurrent with the scanner data (see Table 3 for photo-coverage support data). The overall quality of the aerial photography is very good. The data were obtained under virtually cloud-free conditions.

D. Reference Data Acquisition

Reference data for the study is comprised of: 1) 7.5' and 15' USGS topographical maps (scale; 1:24,000 and 1:62,500, respectively), 2) South Carolina Highway Department county maps (scale; 1:124,750), 3) aerial photography, 4) notes from visit to the study site.

The aerial photography was obtained from the NC-130 aircraft, as indicated in the previous section, and from the USFA Rocky Mountain Forest and Range Experiment Station, courtesy of Mr. Robert Aldrich. The USFS photos were obtained in 1977 over portions of the study area and include: 1) 1:35,000 CIR prints taken in both the spring and fall, 2) 1:12,000 color prints taken in the spring, 3) 1:6,000 70mm color transparencies taken in the spring, 4) 1:2,000 70mm color transparencies

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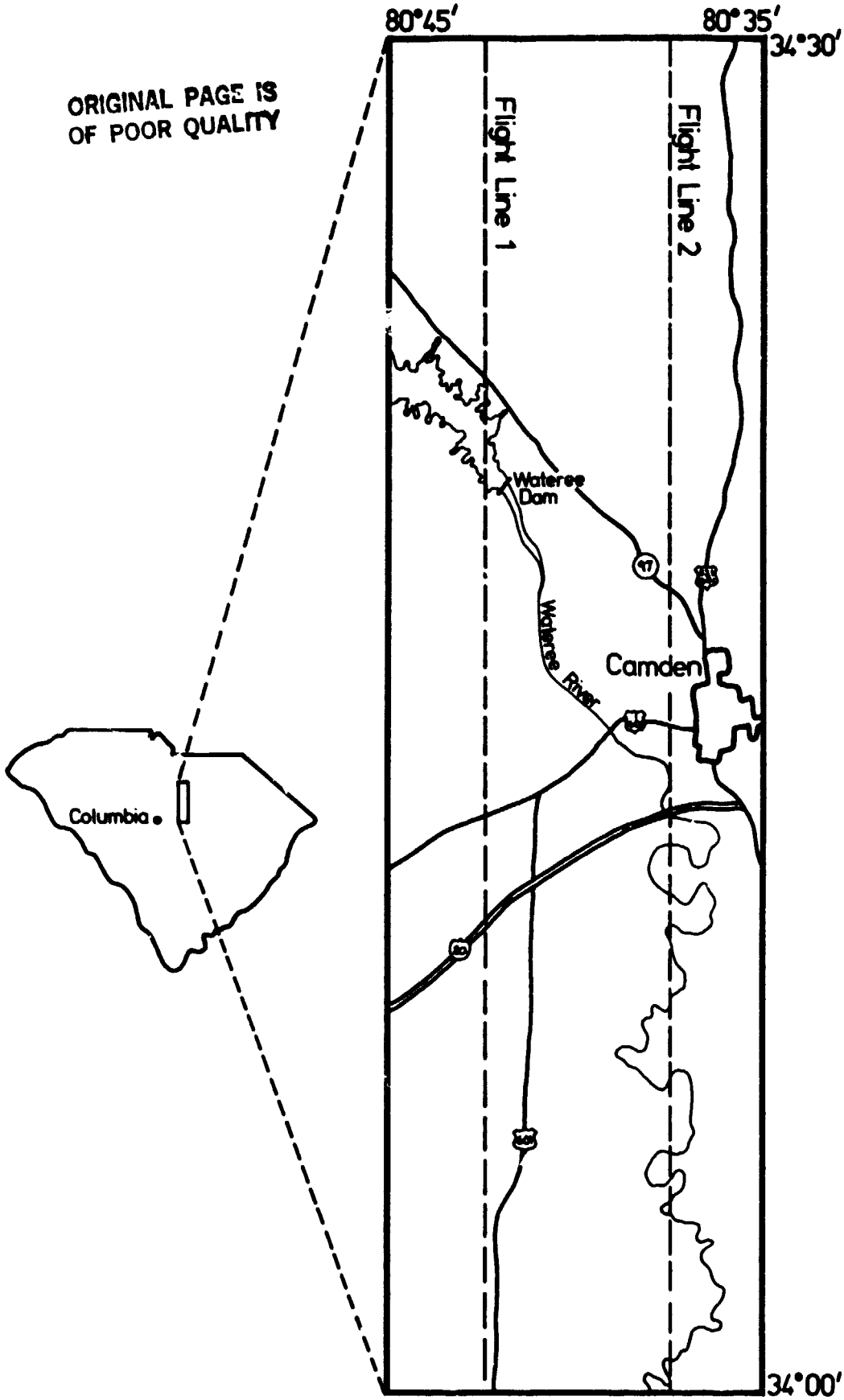

Figure 1. Location and schematic representation of the South Carolina study area.

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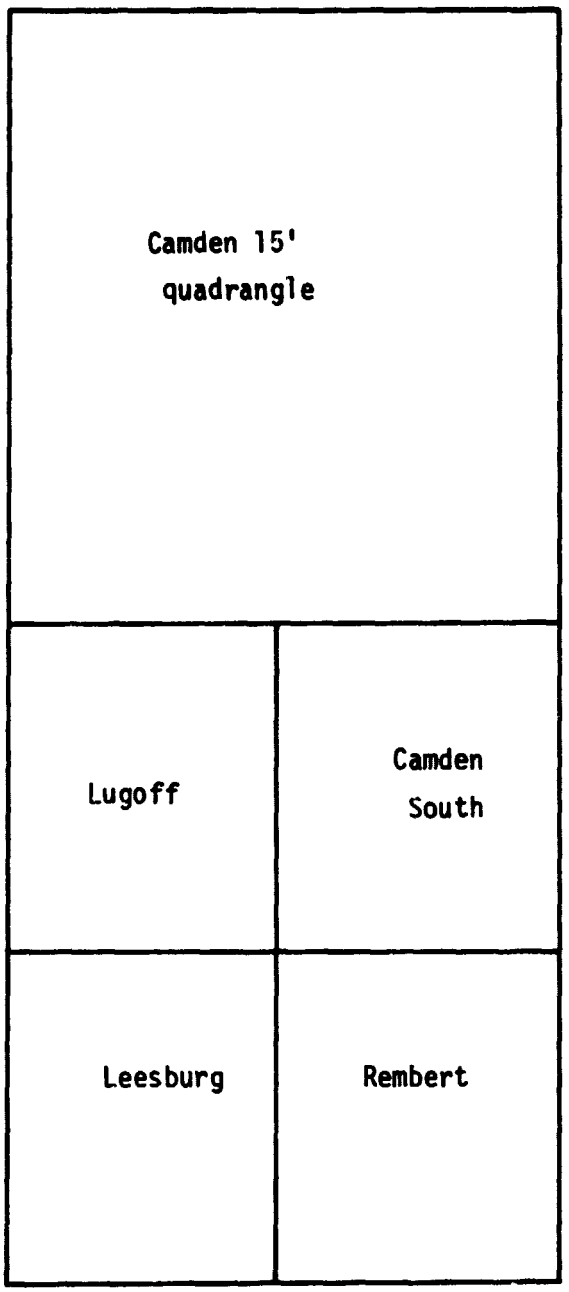

Figure 2. USGS topographical map coverage of the Kershaw County study area.

taken in the spring. The scope and quality of the photo-coverage is considered excellent. The aerial photography in conjunction with the information obtained from the visits to the site should provide highly accurate and detailed information for training and test field identification.

Enlargements were made of the 1:40,000 CIR photography of the May 2nd NC-130 mission. The 1:20,000 black and white photo products were obtained to facilitate accurate recording of observations regarding cover type characteristics made during field visits.

On-site examinations of the study area was conducted from May 10 to May 15. Agriculture Stabilization and Conservation Service air-photo mosaics were examined prior to the actual field work. This generated an initial idea of the diversity of cover types, variability of the spectral characteristics within each cover type, the size of the contiguous areas of the same cover type, the scale of the regional homogeneity, ease of access, and a general introduction to the area. A list of cover types, tenatively defined from examination of the aerial photography, and the region of their occurrence was constructed to direct field visits.

Documentation of site cover type identification, characteristics, and location was accomplished by numerical coding of the sites on the USGS maps, coupled with equivalently coded notes (see Appendix A). A sufficient number of sites were visited to include all major cover types believed to be present and to provide a fair sampling of the variability within each cover type.

Perusal of the color IR trarsparencies (taken concurrently with the MSS data) revealed areas of a spectrally distinct component of the bottomland hardwood community. This was not detected on the ASCS black and white photography and no directed effort to visit these sites was therefore made at that time. The location of these areas has been flagged and on-site identification of the cover type will be made during the early fall study site visit.

E. Construction of the Cover Type Map

A cover type map is being prepared to provide: 1) a benchmark for the evaluation of map output from the classification results employing the various spatial and spectral configurations, 2) a visual representation of the location, distribution, and area of the major cover types of the site. The map will serve in the selection and characterization of the training and test fields. It will also aid in interpreting the fall data and photography.

The minimum mapping unit is approximately 5 acres. Contiguous areas of 5 acres or more were not mapped when less than 0.125 map inches (ie., app. 200 ground feet) across at the widest point.

The cover type units employed are designed to provide a maximum of user oriented information while attempting to maximize the correlation between cover type unit and separable spectral reflectance pattern. A list of all cover type delineations used in the cover type map construction, and their definitions, is provided in Appendix B.

Table 1. Flight Mission Support Data

DC-130 Aircraft Flight Line Coordinates

Flight Line No.	Length of Flight Line (naut. miles)	NFAP Flight Line No.	North End	South End
1	30	17	34 30.0'N/80 37.5'W	34 00.0'N/80 37.5'W
2	30	18	34 30.0'N/80 42.5'W	34 00.0'N/80 42.5'W
3	15	22	34 15.0'N/81 32.5'W	34 30.0'N/81 32.5'W

RB-57 Aircraft Flight Line Coordinates

Flight Line No.	North End	South End
1	34^{o} 30.0'N/80^{o} 22.0'W	34^{o} 00.0'N/80^{o} 22.0'W
2	34^{o} 30.0'N/80^{o} 27.0'W	34^{o} 30.0'N/80^{o} 27.0'W
3	34^{o} 45.0'N/81^{o} 17.0'W	34^{o} 30.0'N/81^{o} 17.0'W

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Table 2. Channel configuration of the NS001 and proposed Thematic Mapper Scanner systems.

NS001		Thematic Mapper	
Channel Number	Band	Channel Number	Band
1	0.45 - 0.52	1	0.45 - 0.52
2	0.52 - 0.60	2	0.52 - 0.60
3	0.63 - 0.69	3	0.63 - 0.69
4	0.76 - 0.90	4	0.76 - 0.90
5	1.00 - 1.30	no corresponding channel	
6	1.55 - 1.75	5	1.55 - 1.75
*7	2.08 - 2.35	6	2.08 - 2.35
8	10.4 - 12.50	7	10.4 - 12.5

*Channel 7 of the NS001 scanner was inseparable during data collection mission of May 2, 1979.

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Table 3. Aerial Photography Support Summary

Flight line	Run time	Altitude (kft) MSL	Altitude (kft) MGD	Line miles	Ground speed
1	5 min	20	19.5	30	240 knots
2	5 min	20	19.5	30	240 knots
3	3 min	20	19.5	15	240 knots

Film type	Camera type	Filter #1	Filter #2	Shutter speed	Factor	ASA	Focal length	Forward lap	Side lap	Roll #
2443(CIR)	Zeiss	12	36AV	1/200	2	80	6"	65%	15%	14
S0397(C)	Zeiss	2A	36AV	1/400	2	160	6"	65%	15%	15

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F. Reformatting and Geometric Correction of the MSS Data

The MSS CCT data were received from NASA/JSC on July 31, 1977, and were in LARSYS format. Ancillary support data, however, was not contained in the header and is being inserted. As part of the reformatting, the flight-lines and individual scan lines are also being reversed, so that they can be displayed with north at the top of the image and without a mirror-image effect in the scan lines. Varian image output indicated some degree of overscan (by an approximate factor of two), which causes severe geometric distortion in the raw data, but can be largely eliminated by displaying alternate scan lines. However, geometric distortion also results from the scan angle. A program was written that computes the pixel dimensions as a function of pixel count (and angular displacement) from nadir. This will be used in determining the best pixel dimensions to use in pixel standardization, and in evaluating possible sources of radiometric variance. A geometrically corrected data set will be generated during the next quarter.

G. Landsat Data Acquisition

Information regarding image characteristics for Landsat MSS data for dates approximating the NC-130 mission has been difficult to obtain, due to the backlog of scene transmittal from Goddard Space Flight Center (GSFC) to EROS Data Center (EDC). The backlog was created by the conversion of the Image Processing Facility (IPF) from a checkout mode to an operational mode(1). This backlog is expected to be worked off in approximately a month. Compounding this problem, Landsat-3 had line-start pulse problems which were detected on April 9. The system was placed in an engineering mode in an attempt to discern the cause of, and subsequently amend, the anomaly. No basis of the problem was determined, but the system was returned to the operational mode on April 29 for data acquisition over the U.S. where cloud cover was less than 30%. Personal communications with Robert Fienberg, of GSFC, indicated that the May 4th Landsat data (the ideal overpass in relation to the May 2 aircraft data collection) was not in existence.

Arrangements for acquisition of the May 13, 1979 overpass of LANDSAT 2 (Path 18, Row 36; frame ID #21572-15120) have been made and preferential reformatting work is being done at GSFC to prompt the transmittal to EROS Data Center.

II. PROBLEMS ENCOUNTERED

Three major problems encountered during this quarter were:

1) The RB-57 mission, during which the SAR data was to be collected, was never flown.

2) The most desirable Landsat coverage (ie., the May 4, 1979 Landsat-3 overpass) was not available for reasons stated earlier, and we have still not been able to obtain the May 13 Landsat-2 data due to backlog problems at GSFC.

3) 3) An unusually long delay was experienced between the collection of the aircraft MSS data and receipt of the data in CCT format at LARS (May 2 until July 31).

The exploratory thrust of this study lies largely with the work in SLAR/MSS overlaid data, and the development of machine assisted classification techniques employing SLAR data. The development of techniques to distinguish different cover types of inseparable spectral reflectance patterns on a per pixel basis is one of the major hurdles in the advancement of CAAT of remotely sensed data. Return levels in the microwave region of the spectrum offer a high potential in removing this hurdle. To proceed toward the stated objectives of the project, however, SAR data from the test site area is required.

Acquisition of radar data was considered from two alternate sources. SEASAT radar data was considered, but due to the waveband employed (L-Band; 1-2 GHz frequency, or 15-30 cm wavelength), it is though to be less desirable than X or K-band data for vegetation cover type classification efforts. Goodyear Aerospace Corporation has high quality X-Band (2.40-3.75 cm wavelength) imagery available to the public. A request for information regarding the availability of imagery over the study site has been made.

Landsat-II data for the May 13 overpass of the study area have been ordered from EDC. However, it is not clear when the data will be processed at GSFC and transmitted to EDC. Therefore, it is uncertain how long it will be until the data are received at LARS, and when subsequent phases of the data analysis can be initiated.

The delay in receiving the CCT's of aircraft MSS data caused some delays in reformatting and processing, but work on this data set is now progressing satisfactorily.

III. PERSONNEL STATUS

The following personnel committed the respective percentages of time to the work thus far completed.

Name	Position	Effort
Anuta, Paul	Reformatting/preprocessing	10
Crosley, R.	Research Assistant	67
Hoffer, R.	Principle Investigator	37
Kline, N.	Secretary	3
Latty, R.	Research Associate	67
Peterson, J.	Associate Director	3
Prather, B.	Secretary	25

IV. ANTICIPATED ACCOMPLISHMENTS

The following represent the expected accomplishments for the coming quarter (September 1, 1979 - November 30, 1979).

1) Geometric and Radiometric correction of the 5/02/79 MSS data.

Approaches to standardizing the pixel dimensions across the image swath are currently being considered. Radiometric distortions due to scanner look-angle (both backscatter and specular reflectance effects) were observed in the Varian images. The amount of radiometric variance along the scan line and the significance of this variance is being studied. Pixel dimension standardization and determination of the significance of radiometric variance (with subsequent normalization, if deemed necessary) will be completed during the coming quarter. Preliminary analysis of the data will be initiated.

2) Acquisition and Preprocessing of LANDSAT 2 Data

As stated previously, LANDSAT 2 data for the May 13, 1979 overpass has been ordered. Arrival is anticipated for the coming quarter. Isolation of the data representing the study area, reformatting and geometric correction will be conducted during this next quarter, contingent on the timely arrival of the data.

3) Selection and Characterization of Training and Test Fields

Representative training blocks and a test data set will be defined in the MSS data.

4) Work with the JSC Mission Manager and NFA Program staff to prepare for the fall aircraft flight mission over the test site will be conducted.

5) Reference data will be collected in the test site at the time of the fall aircraft data collection mission.

6) Design of classification techniques introducing the SAR data so as to maximally supplement information extraction using MSS data will be started during the coming quarter.

7) Fall MSS data will be reformatted, geometrically and (if need be) radiometrically corrected. Arrangements will be made to have the radar imagery digitized, assuming a prompt turn-around of the data.

APPENDIX A

Descriptions of cover types, and their corresponding map location designators, observed during the May 10-15 visit to the study site.

number	description
1	app. 15 year old pine plantation w/red maple, sweet gum reaching canopy height; dogwood, redbud and confederate jasmine in the understory; canopy openings infrequent but large enough to be sig.
2	app. 40 year old pine stand; sweet gum/red maple understory, seldom reaching canopy height; stand stocking irregular, large openings infrequent.
3	Sawney's Creek; assorted bottomland tree species - red maple, sweet gum, tupelo; many covered with muscadine and conf. jasmine.
4	Pasture S of creek, W or road; invader species present; forbs, some shrubs.
5	Two pastures alongside the road with a fence-row between; appears to be a field on the other side but not identified.
6,7	All recently plowed fields; an area of low land in the center, left unplowed - all forbs and very low shrubs.
8	Recently emerged corn 6 to 10 inches high.
9	Old fallow field, misc. forbs and grasses.
10	Recently emerged corn, 6-10 inches high.
11	Recently thinned pine stand, slash exposed and abundant, residual canopy sparse (LT 20%).
12	Improved pasture, lush, variety of grass spp., distribution of spp. and spectral char. homogeneous.
13	Fallow field, mostly misc. forbs, some grasses.
14	Recently emerged corn; 1st field east of creek bottomland.
15	Horsehead Branch; mixed deciduous trees.
16	Winter rye, complete ground coverage, 10-14" high 1st field W of creek bottomland.
17	(Lugoff) Pecan orchard. Foliage bright green, crowns geometrically distributed, GT 75% closure.
18	Young pine plantation; most of the cover is turkey oak and blackjack oak.
19	All bottomland hardwoods.

number	description
20	Winter wheat
21	Winter wheat, app 20" high, light green
22	Winter wheat, 3 1/2' high, light gold/yellow. From Camden, south on SR 521 to SR 261 (to Boyton), most of the cover is pine plantation. The young pine plantations (LT 7 years, app) are mostly comprised of red maple, sweetgum, misc forbs and shrubs, in terms of ground cover.
23	Pasture; many of the grass spp. are in boot.
24	Corn; app. 2' high.
25	Corn; app. 2' high.
26	Many fields in a mosaic; mostly corn, some winter wheat, some recently plowed.
27	Field just beyond Swift Creek; winter wheat 2 1/2-3' high.
28	Field up beyond #27 (SSE), very large, all corn Rembrandt Quad.
29	Field between Rafting Creek and Rafting Creek Church; mature winter wheat.
30	Two adjacent fields; fallow, mostly forbs, some grasses, basically low LAI.
31	Plowed fields, all bare soil.
32	Fallow fields, mostly forbs, low LAI.
33	Oats, substantial weed encroachment. Oats are only about 1-1 1/2' high.
34	Very young soybeans; 3-6" high.
35	Corn; 18"-2' high.
36	Corn; 18"-2' high.
37	Pecan trees.
38	Winter Wheat; 2-2 1/2' high, dense planting, irregular field in and among a wooded area.
39	Large water filled surface mining area.
40	Bottomland hardwood spp., red maple, sweetgum. Camden Quad.

number	description
41	Saunder's Creek; bottomland hardwood, red maple, sweetgum, tupelo.
42	Granie's Creek; bottomland hardwood spp, red maple, sweetgum, tupelo.
43	Mature Pine (slash); GT 50% crown closure, understory present but suppressed.
44	Pine plantation (app. 8-10 year growth; 15ft. max.) well stocked, irregularly spaced, major component of the scene is pine.
45	Mature pine stand, crown closure LT #43, understory and subdominant hardwoods prob. significant component of the reflectance properties.
46	Pine plantations (app. 7-12 years, max 15 ft. ht); grasses and shrubs compose a substantial part of reflectance properties.
47	Pine stand, app 15-20 ft high, well stocked, pine the major component of the reflectance properties.
48	Pine stand, 20-30 ft high, well stocked, understory developed only in places, input to reflectance minimal.
49	Old pasture; ungrazed for a considerable period. Dried plumes of sorrel, broomsedge, bushy beard bluestem appear abundant from grazing view angle.
50	Small field just opposite Hwy 58 of the clear-cut area.
51	Clearcut; slash and stumps windrowed; cover mostly bare soil and slash residue. Gully bottom left wooded.
52	Creek bottom; mostly bottomland hardwood spp.; composition different than lower areas in the county ash, sycamore, water oak, water chestnut oak, red and maple, and sweetgum.
53	Area cleared of tall brush, no pine regrowth to speak of, ground cover mostly Heterotheca trichophylla and dog fennel stalks.
54	Small field covered almost entirely with some bulbous rooted monocot (insufficient development to be keyed) located atop a ridge, covering areas on either side of the road.
55	Clear-cut; all pines were cut, hardwoods were left standing, slash was left distributed, slash abundant.

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number	description
56	Young pine plantation; pines app 3' high, ground cover mostly red maple, sumac, broomsedge, Rubue spp. and Prunus spp., gullies were left wooded.
57	Very young pine plantation (large area-wise); pines LT 18" high; ground cover mostly misc forbs and grasses, Rubus spp., muscadine, broomsdege, sumac and dog [illegible]nnel clums.
58	Pine stand, 20-30 ft high, understory insig., no other species occupying canopy or subdominant pos., crown closure GT 80%.
59	Very large area of pine regeneration; pines range 2-6' high, soil is sandier than the high clay content soils of the areas adjacent to the reservoir. Bare soil, assorted forbs, broomsedge, and other grasses compose most of the ground cover. Major gullies are left wooded.
60	Large cutover area; all pines were cut, hardwoods were left standing Ground cover predominantly slash and hardwoods.
61	Pine stand, 8-10 ft.; stocking is high; leaders make the reflectance such that the canopy looks much like tasseled corn (from a grazing angle); some red maple is present but pine is the dominant cover.
62	Clear-cut and raked into windrows; little or no vegetation as ground cover, mostly exposed soil and exposed roots.
63	Young pine plantation; app. 10-15 ft high.
64	Pasture, very irregular; Juncus spp. abundant near stream; Juncus spp. and shrubs abundant on the south side of the road. Field is bounded primarily by hardwood cover. Four pasture areas intersect with the road, broken by intermittent low areas occuppied by bottomland hardwood spp.
66	Pasture (located adjacent to the corner of the two roads)
67	Disced field; all bare soil.
68	Disced field, all bare soil.
69	Pasture of assorted grasses.
70	Granite quary.
71	Disced field; all bare soil.
72	Pasture.

number	description
73	Large cutover area; alot of slash and small hardwoods were left. Soil is sandier, not as much iron-oxide, as compared to soils more proximal to the reservoir.
74	Winter wheat in the northern most field. Grass in the field to the sourth (two adjacent fields). East of the road, in the middle of the fields is a pond.
75	Corn field; corn is about 12-20" high; iron-oxide soils; planting was not uniformly successful.
76	Area that has been site prepared; slash dozed into windrows; confederate jasmine, honey suckle, misc. grasses and forbs dominate the ground cover. The area is bounded primarily by hardwood cover.
77	Pine stand; dense stocking; pine is the dominant if not the sole component of the scene (verticle); trees 20-30' tall.
78	Young pine stand; app. 10-15' high; densely stocked.
79	Young pine stand; 10-15' high; not as heavily stocked as point #78; understory is well developed and consists of sumac, Rubus spp., red maple, confederate jasmine, virginia creeper.
80	Large area just being dozed; slash is in windrows; cover is almost all bare soil and slash residue, no vegetation cover to speak of; gullies were left wooded.
81	Irregular pattern field of winter wheat; 18-24" high.
82	Winter wheat; fields very small and irregular.
83	Bottomland hardwoods.
84	Area has been site prepared; slash has been windrowed and burned; LT 30% vegetation ground cover.

APPENDIX B

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Cover Types of Kershaw County Study Area: delineations used in the preparation of the area cover type map.

Forest (F)

1) Conifer

cs) Conifer with slash

c : 65-100%

i : 35-65%

p : -35%

c) Conifer w/out slash

c : 65-100%

i : 35-65%

p : -35%

2) Deciduous

ds) Deciduous with slash

c : 65-100%

i : 35-65%

p : -35%

d) Deciduous w/out slash

c : 65-100%

i : 35-65%

p : -35%

3) Mixed - conifer and deciduous

ms) Mixed with slash

c : 65-100%

i : 35-65%

p : -35%

m) Mixed w/out slash

c : 65-100%

i : 35-65%

p : -35%

4) Recent Clearcut - slash randomly distributed and is a major component of the ground cover.

5) Site Prepared Clearcut - bare soil, slash is windrowed or otherwise removed.

6) Regeneration or Old Clearcut - herbaceous and shrublike vegetative ground cover.

Nonforested Wetlands (N)

1) Inundated soils - little or no vegetation, emergent or floating where present.

2) Shrubs and Herbaceous vegetation

Herbaceous (H)

1) Grasses and forbs

2) Shrubs, grasses, and forbs

Agriculture (A)

1) Bare Soil - recently tilled fields
2) Grasses and herbaceous cover - pasture and fallow fields
3) Small Grains - cats, rye, barley, winter wheat, ...
4) Fruit/nut trees

Barren Land (B)

1) Surface Mine; pit and spoil.

Urban (U)

1) Residential - concrete, grass, tree mix
2) Commercial/Industrial - concrete, asphalt, and bare soil
3) Transportation - bare soil, vegetation mix and asphalt, vegetation mix.

Water (W)

Cover Type Definitions:

Forest - all areas of over 35% crown closure of tree species are considered predominantly forest. An area may be predominantly something other than forest where crown closure is less than 35%. In this case the forest designation would follow the designator of the predominant cover type (eg., HlFlcp).

Conifer - all areas having coniferous trees in the presence of not more than 25% deciduous trees. Conifer, as used here, includes all pines, hemlock, tamarack, and cedars.

Deciduous - all areas having deciduous trees in the presence of not more than 25% coniferous trees. Deciduous, as used here, includes, but is not restricted to, sugar maple, red maple, ash, poplar, oaks, sweet gum, tupelos, dogwood, hickery, and horse chestnut.

Mixed - all areas where coniferous trees are in the presence of more than 25% deciduous trees, or vice versa.

With Slash - where a predominantly forest cover type occurs with the slash residues of thinning or selection cutting remaining on the ground.

Without Slash - where a predominantly forest cover type occurs with no slash residues remaining. This includes areas where thinning or selection cutting was followed by slash burning or windrowing, such that slash is no longer a major or significant component of the ground cover.

c : 65-100% - where the forest cover type identified has an average crown closure over the mapping unit of 65-100% ("c" means continuous").

i : 35-65% - where the forest cover type identified has an average crown closure over the mapping unit of 35-65% ("i" means "interupted").

p : -35% - where the forest cover type identified has an average crown closure over the mapping unit of up to 35% ("p" means "park-like"). This designation will most often accompany a forest cover type designator displayed after some other major cover type (eg., HlFlcp; where the ground cover is predominantly herbaceous with a park-like density of coniferous overstory). The forest designation follows since it is subordinate in extent of cover to the foremost designated cover type.

Recent Clearcut - areas of predominantly slash ground cover. Slash may occur in the presence of herbaceous and shrub cover with some residual trees. Areas of greater than 10% residual crown closure are to be designated the appropriate forest cover with slash.

Site Prepared Clearcut - areas of predominantly bare soil (vegetative ground cover of less than 35%) where all slash has been windrowed, burned, or otherwise removed.

Regeneration or Old Clearcut - areas of predominantly herbaceous/shrub ground cover (greater than 35%) where signs of site preparation are evidenced as in windrowed slash, machined contours, ditching, etc.

Nonforested Wetlands - areas consisting of "seasonally flooded basins, flats, meadows, marshes, and bogs". Designation is restricted to areas of less than 35% tree cover.

Inundated Soils - areas that are covered with standing water, where the underlying soil is detectable or vegetation is floating or emergent.

Shrubs and Herbaceous vegetation - low areas of saturated or periodically inundated soils where the predominant vegetation cover is shrub and/or herb.

Herbaceous - areas consisting of predominantly herbaceous and/or shrub cover. If trees are present, they must occur with less than 35% crown closure. This cover type will often be found in conjunction with tree cover. The designation is to be restricted to those areas not produced by clearcutting practices, power or gas line right-of-ways, nor rotational agricultural practices.

Grasses and Forbs - areas covered with grass and forb to the exclusion of shrub type cover (shrub cover less than 25%).

Shrubs, Grasses, and Forbs - areas covered with grasses, shrubs, and forbs.

Agriculture - land used "for production of farm commodities". This delineation is assigned on a basis of land-use moreso than cover type. It includes all areas used in farming operations whether currently used in crop or feed production or not.

Bare Soil - this includes all areas of bare soil associated with agricultural operations. The vast majority of these areas are planted in row crops.

Grass and Herbaceous cover - includes all areas of grass and herb associated with agricultural operations (herbs used here excludes all row and small grain crops typically planted in monocultures). These areas consist primarily of pasture and fallow field. Areas of less than 35% tree crown closure which have pasture grass understories (as may be evidenced by soil exposure patterns associated with grazing) are included in this category.

Small Grains - areas planted in small grain crops such as barley, oats, rye, wheat, winter wheat, ..., etc.

Fruit/nut trees - areas planted in orchards, groves, or other arrangements of fruit or nut trees comprising entire mapping units. Small plantings on farmstead grounds are not included in this category.

Barren Land

Surface Mine; pit and spoil - includes all areas directly included in and affected by mining operations. These are the location of the extraction or barrow pit, the areas of spoil deposition and accumulation, and areas of processing and sorting.

Urban - consists of areas that are covered with man-made structures and materials. It includes cities, towns, settled areas along highways and roads, railroads, roads and highways, industrial complexes, mills, institutions, airports, etc. Individual houses or groupings of houses less than the minimal mapping unit are not designated urban.

Residential - areas comprised of housing units on contiguous lots with tree and grass cover constituting not less than 10% of the cover.

Commercial/Industrial - areas comprised of structures for commercial or industrial use. Ground cover consists primarily of asphalt and concrete. Some bare soil or refuse accumulations may be associated with some of the industrial operations.

Transportation - includes all areas covered by structures directly employed in transportation. This includes highways, dirt roads, railroad tracks, and airport runways. It does not include skid trails through cut-over areas, nor perimeter roads around field boundaries.

Water - all areas of standing, open water where soil and vegetation are not detectable.

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